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ORIGINAL ARTICLE

Public health and natural disasters: disaster preparedness and response in health systems

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Abstract The number of natural disasters and the severity of their impact have increased in recent decades. These developments highlight the need for improved preparedness and response in the health sector, inter alia, and the important role of public health in disaster management. The purpose of this paper, which is based on a literature review, is to provide background information about the general framework of disaster management and present the core concepts of disaster preparedness and response in health systems. Three different strategies were used to collect information for this article. First, information was collected from various international databases. Then, the virtual health library for disasters provided by the World Health Organization (WHO) and the WHO Health Action in Crisis (HAC) online sources were reviewed for relevant WHO and Pan American Health Organization (PAHO) books, working papers and reports. Finally, PubMed abstracts were searched with key words and phrases. For greater completeness, five disaster journals were hand searched. Additional sources such as text books, working papers, and articles were included, relying on the bibliography of the original study mentioned in the introduction to this paper. The studies reviewed indicated that fragmented and response-oriented approaches have begun to change world wide, at least in the literature. Despite the publication of increasing numbers of research projects in disaster issues, there are still gaps in sharing experience through scientific papers, such as systematic evaluation of activities in different phases of disaster situations.

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Introduction

In recent years, disasters have been a current issue for almost all aspects of public health and health systems. This article focuses on the core concepts of preparedness for and response to natural disasters in health systems with the aim of providing background information to help cope with them. The key question posed in the article is: how should health systems prepare for and respond to natural disasters? The article is based on some parts of a master thesis with the same title that was submitted by the author to Bielefeld University. It may be a starting point for academics and practitioners who are interested in natural disasters and help to identify emerging points for future disaster studies.

An overview of the global situation regarding natural disasters

Natural disasters have always affected human health and well-being. Despite developments in knowledge and technology, the impact of natural disasters has increased in severity in recent decades due to the increasing vulnerability of populations as a result of, inter alia, rapid population growth, urbanization, environmental degradation, poverty, and social inequalities (Wisner and Adams 2002; Arnold 2002). There has also been an increase in the number of disasters in recent decades. Although almost all hazards have become more frequent, this is particularly the case with weather-related events. These rose from an annual

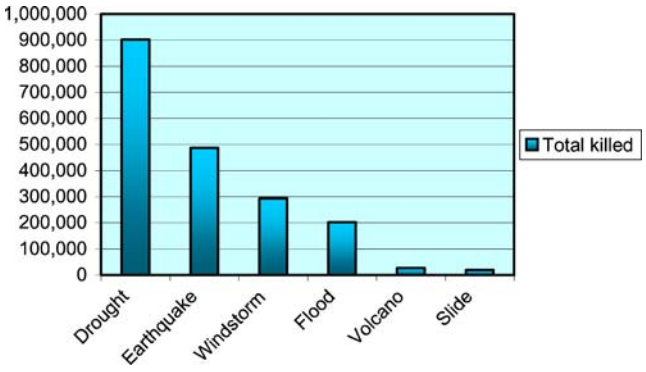

Fig. 1 Types of natural disaster ranked by mortality 1900–2002. Source: With the author's calculations, the figure is adapted from the database of EM-DAT: the OFDA/CRED International Disaster Database, www.cred.be/emdat Université Catholique de Louvain, Brussels, Belgium

average of 200 between 1993 and 1997 to 331 between 1998 and 2002 (IFRC 2003).

Increased economic loss is also becoming more important as a consequence of natural disasters (IDNDR-DIRDN 1996). The main reasons for this are urbanization; increased material values, especially in urban areas and industrialized countries; the concentration of too many political, industrial, financial, or other resources in one urban area; the domino effect[1]; and the globalization effect[2].

Records of the last century show that of all weather-related hazards, drought, earthquake, windstorm, and flood affected the greatest numbers of people (Fig. 1). Of these, earthquakes present the greatest risk of death for those affected (Guha-Sapir and Lechat 1986).

In the modern world, urban areas are at highest risk of disaster since that is where all the factors that make populations more vulnerable are seen. Each year, more people move to urban areas: the global urban population was 47.2% in 2000 and is estimated to rise to 49.3% in 2005 (UN 2003). In view of the fact that the most crowded cities of the world are in areas that are at extremely high risk of natural disasters (ISDR 2002), it is clear that special attention should be given to developing projects covering urban preparedness.

[1]Natural hazards can trigger technological hazards, which cause environmental and humanitarian disasters, especially in industrial infrastructure areas where extreme natural hazards, such as earthquakes or floods, can result in environmental disasters (UN-ISDR 2002).

[2]Modern societies are more dependent on services and infrastructure, including transport, water and sewerage, electricity, gas, drainage, storage facilities, and communications networks. Natural or other disasters causing a failure of these services can have considerable consequences, even for people in areas not directly affected (UN-ISDR 2002).

After the Indian Ocean earthquake and tsunami at the end of 2004, over 230,000 people were missing or confirmed dead (WHO 2005) while the numbers and effects of the hurricanes in the United States and Central America and the earthquake in Kashmir in 2005 are still unclear. The contribution of man-made and natural disasters to the global disease burden is expected to climb from twelfth place in 1998 to eighth place in 2020 (Global Forum Health Research 2001). The World Meteorological Organization (WMO) has estimated that the impact of natural disasters on the world economy is US $50 billion annually (Pan African News Agency-PANA 1999). Windstorm (US $490,085,364,000), floods (US $361,031530,000), and earthquakes (US $315,440,208,000) caused the highest damage in economic terms in the world between 1900 and 2004. In the same period, the total reported damage caused by natural disasters[3] was US $ 1,271,295,529,000 (EMDAT Disaster Database 2006) (Table 1).

The 2005 floods in Europe and hurricanes in the USA also reminded us that natural disasters do not only affect developing countries: they are global problems, and no country is safe from them.

Public health and natural disasters

Natural disasters affect communities in various economic and social ways. As well as the effects on public services such as water, sewerage, and energy, the massive adverse impact of natural disasters on the health of populations has also led to them being acknowledged as public health problems (Noji 1997). These impacts include unexpectedly high numbers of deaths, injuries, or illnesses in the affected community; destruction of local health infrastructure and routine health services; effects on the environment leading to the danger of communicable diseases and food shortages; mental health problems; and spontaneous or organized population movements (WHO 1994; Noji 1997). Despite the key function of health sector and public health institutions in disaster management, public health is often seen in terms of logistic support. However, these institutions have specialized knowledge of the situations and needs of societies that could enable public health specialists to play a more active role in disaster-related decision-making bodies and disaster management teams. Epidemiological research on disasters is the starting point for prevention and intervention strategies to reduce mortality and morbidity in different types of

[3]Epidemic and insect infestation are not included because they are considered biological hazards, and wildfires are not included because of the debate as to whether they are natural or man-made disasters.

Table 1 Reported damage by natural disasters 1900–2004

Natural disaster type[a]	Reported damage US $ (000s)
Drought	61,276,164
Earthquakes	315,440,208
Extreme temperatures	26,966,447
Famine	93,449
Flood	361,031,530
Slides	4,837,574
Volcano	3,800,446
Wave/surge	7,764,347
Windstorm	490,085,364
Total	1,271,295,529

[a] Epidemic and insect infestation are not included because they are considered biological hazards, and wildfires are not included because of the debate as to whether they are natural or man-made disasters. Source: With the author's calculations, the figure is adapted from the database of EM-DAT: the OFDA/CRED International Disaster Database, www.cred.be/emdat Université Catholique de Louvain, Brussels, Belgium

disaster situations (Noji and Toole 1997). Public health is an important aspect of this. The philosophy underlying public health can contribute to preparedness and prevention efforts, as seen in the debate on primary health care and prevention versus cure (Loretti 2000). The United Nations underlined this as a principle for disaster reduction strategies during the 1990s, with initiatives such as the International Decade for Natural Disaster Reduction (IDNDR) and the International Strategy for Disaster Reduction (ISDR), which were intended to move the debate toward measures that could be taken before disasters occur in order to enhance the impact of response and postdisaster activities through preparedness programs. Both nationally and internationally, however, large amounts of money and resources are still being allocated for direct response activities to disasters.

Methodology

Three different strategies were used to collect information for this article. First, information was collected from United Nations (UN) and International Federation of Red Cross (IFRC) databases and information sources as well as Emergency Disasters Data Base (EM-DAT): The Office of US Foreign Disaser Assistance/Center for Research on the Epidemiology of Disasters (OFDA/CRED) International Disaster Database for the overview of the global situation regarding natural disasters and the section on public health and natural disasters. Second, since the World Health Organization (WHO) has diverse and compact information for disaster preparedness and response in health systems, the virtual health library for disasters provided by WHO and the WHO Health Action in Crisis (HAC) online sources were reviewed for relevant WHO and Pan American Health Organization (PAHO) books, working papers, and reports for the section on disaster preparedness and response in health systems. Finally, PubMed abstracts since 1995 were searched with key words and phrases, such as natural disasters, disaster management, disaster preparedness, mitigation, and response. Articles not containing information about health systems and/or public health and not relevant to the key question were excluded. For greater completeness, five disaster journals were hand searched. Additional sources such as text books, working papers, and articles were included for all sections, relying on the bibliography of the original study mentioned in the introduction to this paper.

Disaster preparedness and response in health systems

The occurrence of natural disasters cannot be wholly predicted or prevented, so disaster management is the main tool for coping with them. Health systems require special attention in disaster management activities due to the vital functions they perform. There is no single template for preparedness and response projects that could be adapted to all natural disasters and to all countries. As well as the hazards and their consequences, societies are unique, and vulnerabilities arise from their social and geographical characteristics. Because of this, each country must develop its own disaster preparedness and response program according to its parameters. Despite these differences, the general idea and aspects for the main components of disaster management do have a lot in common, and past experience from each event in different countries is the most valuable information source for every country. This section of the paper discusses the framework of disaster management in health systems.

A functional disaster preparedness and response program within health systems should be part of a national program and suit the context of the community (WHO 1998). WHO (1998) has constructed the framework of emergency/disaster management on the basis of four approaches: (1) a comprehensive approach that considers all phases of the disaster management sequence (Fig. 2), (2) an all-hazard approach that requires the development and implementation of strategies for the full range of likely emergencies, (3) a multisectoral and intersectoral approach that involves all organizations in emergency management, and (4) the concept of a prepared community that acknowledges community members and resources as the foundation of disaster management programs.

The disaster management sequence is divided into two phases. The risk reduction phase is the phase before a

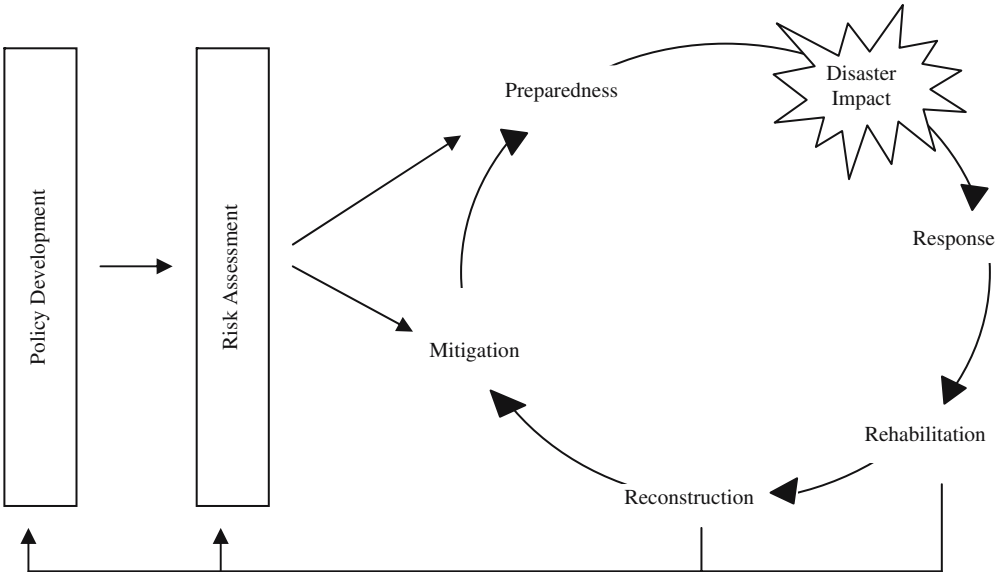

Fig. 2 Disaster management. Source: The figure is adapted by the author from two figures: "Management sequence of disaster and emergencies" (Paho 2000) and "Emergency preparedness process" (WHO 1999)

disaster and includes mitigation and preparedness activities. The recovery phase is the phase after a disaster and includes response, rehabilitation, and reconstruction activities (PAHO 2000).

The risk reduction phase begins with the development of a clear policy and strategy for dealing with disasters (WHO 1999). During the development of policies and strategies for disaster management, the relationship between disasters and development should be kept in mind. Considering disasters in development projects is a perquisite for a good strategy. Modern technology allows for structural measures with a direct influence on mortality and morbidity, but their application needs to be definite, planned, and controlled. For example, the findings of Armenian et al. (1997) and Dedeoglu et al. (2000) show that structural and construction factors (e.g., building height and materials used) are contributing to the possibility of death in earthquake disasters (Armenian et al. 1997; Dedeoglu et al. 2000). As well as structural measures, the cheapest measures are nonstructural options in other sectors, such as limits on the types of land use, legislative interventions, or tax incentives that direct development away from hazard-prone areas (Noji 1997). Policy development is followed by risk assessment, which consists of hazard and vulnerability assessments (WHO/EHA 2002). Risk assessment in health systems requires expertise in a wide spectrum of subjects, such as biology, biostatistics, chemistry, critical care, disaster medicine, earth sciences, emergency medicine, emergency management, engineering, epidemiology, forensics, infectious diseases, law, law enforcement, laboratory medicine, meteorology, microbiology, military science, communications systems, information technology, nuclear science, political science, psychology, public health, public health policy, radiation health, radiation physics, sociology, toxicology, and trauma surgery (Arnold 2005). Hazard assessment refers to the mapping and monitoring of hazards that affect countries or particular regions (PAHO 2000). The aim of vulnerability assessment is to identify weaknesses in a system that may be exposed to hazards. It is based on a series of techniques for determining the hazards that may affect a particular community and their possible impact and determines the factors that make a community vulnerable to emergencies and disasters by analyzing its social, infrastructural, economic, and demographic composition (Yahmed and Koob 1996). Many systems and services, such as lifelines, are vital for health care facilities, so vulnerability assessment should be extended to them (Menoni et al. 2000). In risk assessment procedure, possible health damage should be identified and characterized. For example, it is important in risk assessment of health systems to determine the possible numbers of injured or ill people who would require medical care and the possible duration of health damage (Arnold 2005). Once the vulnerable points are determined, vulnerability reduction is carried out through reducing susceptibility and improving resilience (WHO 1999). Weaknesses that can be eliminated or reduced are a matter for mitigation activities. Where there are unavoidable weaknesses, preparedness programs must be developed.

The aim of preparedness is to develop emergency plans, to train personnel at all levels and in all sectors, to educate communities at risk, and to monitor and evaluate these measures regularly (WHO 1999). Once a disaster strikes, the effectiveness of response activities will rely on existing mitigation and preparedness activities and the capacity and accessibility of services in the affected country before the

disaster. An important aspect of these preparedness activities is improvement of health systems and the health of populations. Even a written plan is a fundamental step in preparedness: emergency plans are ongoing processes rather than written plans (Perry and Lindell 2003). Emergency plans might be supported with alternative plans that do not rely on local hospitals, and disaster-medical-assistance teams for disasters that could affect large-scale areas or urban areas with high-density populations (Schultz et al. 1996). According to WHO, the emergency planning process consists of seven steps: design of the project, definition of planning group, analysis of potential problems, resource analysis, description of roles and responsibilities, description of management structure, and development of strategies and systems (WHO 1998). Quarentelli (1997) listed ten criteria for good disaster management.

1. Correct recognition of differences between response- and agent-generated demands. *While agent-generated needs vary depending upon the disaster impact and the specific nature of the agent, response-generated demands, such as coordination, mobilization of personnel and resources, and proper delegation of tasks are common to all disasters*.
2. Adequate carrying out of generic functions *that may be used in various disaster events, such as setting up temporary settlements and rescue and first-aid activities*
3. Effective mobilization of personnel and resources
4. Appropriate delegation of tasks and division of labor
5. Adequate processing of information
6. Proper decision making
7. Development of overall coordination
8. Blending emergent and established organizational behavior
9. Provision of appropriate reports for the news media
10. Establishment of a well-functioning emergency operation center (Quarentelli 1997: 39; italics added).

Staff and community training is an essential part of preparedness activities, which contribute to the effectiveness of the response. "Training prepares workers for physical and psychological demands that could emerge across a range of possible disasters." (Paton 1996, p:14). Additionally, training and drills provide better understanding of disasters and improvement of skills and identifies deficiencies in skills, decision making and information systems, and shortages of resources (Hsu et al. 2004). Community training and education increase awareness, inform the community about appropriate action for different types of emergency, and provide an opportunity for members of the community to speak freely about events and scenarios that have not previously been mentioned. Large-scale drills may have the power to affect political willingness to undertake preparedness programs (WHO 1998; Simpson 2002).

The responsibilities of the health sector during response activities are the following:

- Management and treatment of mass casualties
- Epidemiological surveillance and disease control
- Basic sanitation and sanitary engineering
- Environmental health management
- Health management in shelters or temporary settlements
- Food and nutrition
- Management of humanitarian supplies
- Participation in coordinating response activities
- Re–establishment of normal health programs as the first step in the rehabilitation and reconstruction phases (PAHO 1981, 2000).

The personnel who will be included in response activities should be familiar with the plan and types of disaster (PAHO 1995). It is important that experienced personnel are selected and placed in positions in which they will adapt easily and serve effectively in disaster situations. This should be done by encouraging people to come forward for selection rather than charging them with obligatory duties. Contrary to common belief, the need for extra personnel does not occur only in the immediate postdisaster situation (Tekeli-Yeşil 2002). Arrangements for the supply of enough personnel in the medium- and long term, such as twinning cities or hospitals, should be planned for in the preparedness program. Such plans should include consideration of the needs that will arise or become more urgent after a disaster, such as dialysis units after earthquakes or rehabilitation facilities for the disabled (Tekeli-Yeşil 2002).

Many hospitals and health care services have experienced dramatic damage during past events, but generally speaking, hospitals suffer from functional rather than structural collapse. Their services can also be disrupted by nonstructural damage both inside and outside the health service (PAHO 2003). This point should be considered when the location of the health facilities is chosen and during their construction. Both external and internal arrangements of health services are vital for continuance of services during disasters. Special arrangements made in advance for heavy instruments, dangerous materials, strategic objects for the services and so on can help health services avoid destruction or the effects of disasters (PAHO 2003, 2004). As well as health-system plans, hospitals should have their own plans aiming to protect (1) people: patients, staff and visitors and (2) hardware: equipment and

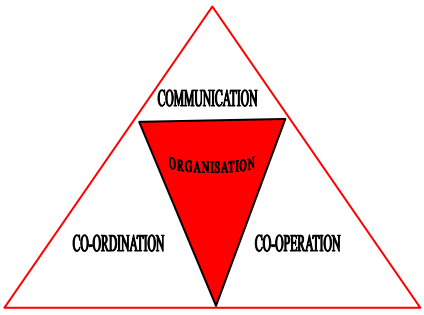

Fig. 3 Main components of an effective response to natural disasters

installations for maintaining the ability to provide services. Hospital disaster planning has four main components: patient and staff safety in case of disaster; management of mass casualties; staff alert, recall, and deployment; and operations control, including information and communication (PAHO 1981).

Experience shows that during the response phase, donations that are usually unsolicited and inappropriate flood in to the disaster area from foreign countries (IFRC 2000), and little has been learned about international assistance. The common myth about disasters that the affected local population needs any kind of international assistance is still believed and practiced. De Ville de Goyet (2000), who listed ten myths about disasters, mentioned the pursuit of self-satisfying social or professional objectives and expectations of donor countries as some of the reasons for unsolicited personnel or supplies. Usually, the affected communities, especially in countries with a large albeit unevenly distributed medical population, can cope with the disasters with their own resources (De Ville de Goyet 2000). Other problems often faced during response activities are lack of coordination, cooperation, and communication (Van Rooyen and Leaning 2005; Hsu et al. 2002; Heath 1995; Kouzmin et al. 1995). Exchange of information and resources through interagency committees, together with preplanning and exercises, are some ways in which coordination, cooperation, and communication can be enhanced among different sectors and agencies (Granot 1999).

In the long term, loss of buying power and increased poverty, which may arise or increase as a consequence of disasters, limit people's access to health services (TTB 2002). Measures should, therefore, be taken to assure the population's access to health services.

Disasters afford an unwelcome opportunity for the socioeconomic redevelopment of areas (Levett et. al. 2005) and for rebuilding communities and sectors resilient in dealing with disasters. Buildings and services destroyed in all sectors, including the health sector, can be rebuilt or rehabilitated during the reconstruction phase.

Conclusion and recommendations

Epidemiological research is very important in mitigating the health effects of disasters and enhancing the effectiveness of response activities and has vital benefits for dealing with future disasters (Noji 2005). It is, therefore, pleasant to see that increasing numbers of results of research projects in disaster issues have been published. However, improvements are still at an early stage. As learning from experience is the strongest and most effective tool in responding to disasters, more resources should be allocated to these subjects, more papers about experience in different countries should be shared, and scientific evaluation of all activities should be undertaken. In addition, international concepts should be agreed upon for investigations during response activities and improvement of registration during the immediate postdisaster phase. Fortunately, the fragmented and response-oriented approach has begun to change world wide, at least in the literature.

As Schultz and his colleagues (1996) stated, because of their high-density populations and inadequate infrastructure, megacities are in particular danger. Alternative plans that do not rely only on local hospitals and conventional emergency teams should be included in preparedness plans to fall back on in chaotic situations that may arise after major events, especially in such cities.

In view of the increasing number of natural disasters and their growing impact on vulnerable populations, it is clear that mitigation and preparedness activities are the most important tools for coping with disasters. Besides preparedness at governmental, sectoral, or institutional levels, preparedness at community and personal levels plays a critical role in reducing the consequences of disasters and sustaining the people's resilience. Additionally, in many disasters, the victims and local people are the first to respond, especially where search and rescue activities are concerned; they can also be isolated or unreachable in the early phases of disasters and thus have no option but to cope with the situation alone. Their involvement and active participation in any kind of mitigation and preparedness activities are therefore vital for coping effectively with natural disasters. Looking to saving lives in the future as well as to those lost in the past, practicing preparedness programs on anniversaries of past events, especially in schools, hospitals, or other related sectors, could be thought of as an appropriate form of commemoration. Training workers and staff is a crucial part of preparedness. Such training should be supported with appropriate materials and content, such as the development of simple, common, therapeutic procedures for possible injuries and health problems resulting from eventual disasters in the country (Tekeli-Yeşil 2002). The above-mentioned study of Armenian et al. (1997) shows that knowledge of injury patterns can

provide valuable information to direct search and rescue efforts for potential survivors.

Unsolicited and inappropriate international donations/assistance is another theme raised in the studies reviewed. Instead of making such donations, which are often made for unstated political and social motives, donors should follow WHO's or other organizations' guidelines for immediate donations and contact the local authorities. National authorities should make and announce a needs assessment for external assistance as fast as possible, where necessary. A more effective alternative would be to support the development of mitigation and preparedness programs and/or recovery activities.

Finally, organization, communication, coordination, and cooperation are vitally important in disaster preparedness and response programs. Organization is the foundation stone, and cooperation, coordination, and communication are the corner stones of such programs. Without them, preparedness and response programs cannot be operated effectively (Fig. 3).

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